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For

**WELL PACKER HAVING AN ENERGIZED SEALING ELEMENT AND
ASSOCIATED METHOD**

By

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WELL PACKER HAVING AN ENERGIZED SEALING ELEMENT AND ASSOCIATED METHOD

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 60/508,721, filed on October 3, 2003.

Background of the Invention

[0002] Field of Invention. The present invention relates to the field of well packers, and particularly to a device and method for energizing a well packer seal element.

[0003] Related Art. Packers are used in oil and gas wells to prevent fluid flow through an annulus formed by a tubing within the well and the wall of the wellbore or casing. The packer is generally integrally connected to the tubing, using, for example, means such as a threaded connection, a ratch-latch assembly, or a J-latch, all of which are well known in the art. The tubing/packer connection generally establishes the seal for the inner radius of the annulus.

[0004] The seal for the outer radius of the annulus is generally established by a deformable element such as rubber or an elastomer. A compressive force is generally applied to the deformable element, causing it to extrude radially outward. The element extends from the outer portion of the packer to the wellbore wall or casing and seals between those structures. Sometimes backup rings are used to prevent undesired extrusion in the axial direction. The deformable element may also incorporate other components such as a metallic mesh or garter spring.

[0005] Existing seal elements sometimes fail due to differences in thermal expansion properties of the deformable element and the surrounding casing or formation. Generally the

rubber or elastomer contracts more in response to a decrease in temperature than does the casing, for example. That can lead to a decrease in contact force and a leak may result.

[0006] Another failure mode common in open hole completions involves a long sleeve of rubber that is inflated to produce the necessary contact force to form a seal against the surrounding formation. If pressure is not maintained on the inner wall of the sleeve, the seal is likely to fail.

[0007] Another type of packer found in the existing art is the steep pitch helix packer described in U.S. Patent No. 6,296,054. That packer relies on helical strips that expand radially outward in response to an applied action to produce the desired seal.

Summary

[0008] The present invention provides for an energized sealing element that maintains a seal under various conditions by providing a source of stored energy that can be used to insure contact forces are maintained.

Brief Description of the Drawings

[0009] The manner in which these objectives and other desirable characteristics can be obtained is explained in the following description and attached drawings in which:

[0010] Figure 1 illustrates an embodiment of a seal element constructed in accordance with the present invention.

[0011] Figures 2A and 2B illustrate the seal element of Figure 1 when the seal element is acted on by a compressive force.

[0012] Figure 3 is a perspective view of an alternate embodiment constructed in accordance with the present invention.

[0013] Figures 4A and 4B illustrate an energizing element in accordance with an embodiment of the present invention.

[0014] Figures 5A and 5B illustrate an energizing element in accordance with an embodiment of the present invention.

[0015] Figure 6 illustrates an energizing element in accordance with an embodiment of the present invention.

[0016] Figure 7 illustrates a plurality of seal elements configured in accordance with an embodiment of the present invention.

[0017] It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

Detailed Description of the Invention

[0018] In the following description, numerous details are set forth to provide an understanding of the present invention. However, it will be understood by those skilled in the art that the present invention may be practiced without these details and that numerous variations or modifications from the described embodiments may be possible.

[0019] The present invention comprises numerous embodiments and associated methods for creating an energized seal as further described below. The seal element of the present

invention is for use in downhole packer applications and may be employed on a variety of packers. For example, the seal element may be used on an open hole-type packer, or it may be used on a packer for use inside a casing, liner, or tubing. In addition, the seal element may be employed on an expandable tubing packer.

[0020] In the embodiment of Figure 1, an energized seal element 10 comprises a seal layer 16, a support sleeve 18, and an energizing element 20. Seal layer 16 is preferably made of rubber or an elastomeric compound, but can be made of thermoplastic or various soft, deformable materials, or metals such as copper or steel capable of forming a metal-to-metal seal. Often only a thin layer of elastomer, rubber, or other seal material is used. Use of a thin layer helps prevent a problem that may occur due to differences in thermal expansion of metal or rock and rubber.

[0021] Support sleeve 18 and energizing element 20 are preferably made of metal, but can be made of various materials such as composite materials that permit the storage of mechanical potential energy. The stored potential energy maintains the contact force needed to create the seal. A shape-memory alloy that assumes an expanded state when exposed to a predetermined temperature may also be used.

[0022] As shown in Figures 1, 2A, and 2B, seal layer 16 is placed over support sleeve 18. Support sleeve 18 covers energizing element 20.

[0023] Various combinations of those structures are possible. For example, sealing layer 16 could in some cases be omitted altogether. In such cases, support sleeve 18 provides the sealing surface to seal against a wall 22. This is possible, for example, in an open-hole section of a borehole if the open-hole section is composed of soft materials and support sleeve 18 is able to

penetrate some distance into the borehole. Also, support sleeve 18 may be embedded in seal layer 16 (*i.e.*, within the elastomer itself). In other cases it may be desirable to omit support sleeve 18 such that energizing element 20 bears directly onto seal layer 16.

[0024] In packers, it is common to compress the seal element to expand the seal into sealing engagement with an outer conduit (*e.g.*, casing or open hole section). Other methods of expanding are also used. For ease of description, the following discussion will primarily focus on the compression type of actuation and engagement. In a compression-set packer, a mandrel typically moves to create the compressive force.

[0025] Referring to Figures 2A and 2B, when seal element 10 is compressed, energizing element 20 pushes support sleeve 18 in a radially outward direction to force seal layer 16 into engagement with wall 22. Energizing element 16 deforms elastically (at least in part) when compressed, and creates a reserve of energy that keeps support sleeve 18 pressed radially outward.

[0026] Any of the embodiments herein may use a bi-metallic material to increase the force applied by energizing element 20. A bimetallic material may be designed to deform in a certain direction as the energizing element is exposed to higher (or lower) temperatures.

[0027] As stated above, support sleeve 18 is not always necessary. For example, energizing element 20 and seal layer 16 may be designed to prevent the seal layer 16 from extruding through any openings in energizing element 20. Figure 3 shows an example of such an embodiment. Energizing element 20 comprises slotted members 24 and the seal layer 16 encloses energizing element 20.

[0028] Seal element 10 may be precisely located and can produce high contact forces. In an open hole this allows the seal to penetrate the formation. In a cased hole, this will increase the sealing capacity.

[0029] There are many ways to energize seal element 20. In one embodiment, energizing element 20 may be a spring 26 placed behind support sleeve 18. Spring 26 may be a coil-type, wound tightly and held in place by a pin or weld. Once seal element 10 is in the proper position, spring 26 may be released to uncoil and expand, thereby providing a radially energizing action against seal layer 16.

[0030] Energizing element 20 may also comprise a bi-stable element such as a bi-stable expandable tubing expanded behind the seal layer 16. A bi-stable expandable tubing is described in U.S. published application no. US20020092658, published July 18, 2002, and incorporated herein by reference.

[0031] In another embodiment, energizing element 20 is a swelling material positioned behind support sleeve 18. For example, energizing element 20 may be a material that swells when exposed to some other material. Once the packer is in the desired position, the swelling material is mixed with a reactant and caused to swell. The swellable energizing element 20 may be used in conjunction with a standard setting mechanism or the energizing elements discussed above. For example, the packer may be set by compression and then energized further with a swellable material.

[0032] In another embodiment, energizing element 20 could be a bag or container which is energized with gas or other compressible material and placed beneath seal layer 16. The bag can be compressed at its ends once the packer is in the proper position downhole. The

compression of the bag will cause the bag to compress lengthwise and expand radially to energize the seal element 10. A gas chamber or spring behind a piston could maintain the compression to keep the seal energized.

[0033] A spiral spring 28 as shown in Figures 4A and 4B can be used as energizing element 20. This option could be constructed of either a long length of metal or as a succession of small independent springs. Figure 4A shows spring 28 in its compressed state and Figure 4B shows spring 28 in its expanded state.

[0034] Another option would be to use a bow 30 as energizing element 20, as shown in Figures 5A. and 5B Bow 30 will move outward when engaged by wedge 32. When bow 30 contacts support sleeve 18, bow 30 will elasticity deform and store mechanical energy.

[0035] Instead of using piecewise parts, a tube 34 with slots 36 can be used. Slots 36 can be helical or straight. Figure 6 shows tube 34 with helical slots 36. Tube 34 will expand when compressed axially.

[0036] Multiple layers of tubes 34 or energizing elements 20 could be used to increase the energy stored.

[0037] In addition, the present invention may provide alternate flow paths and cable/control line feed-throughs, and it may provide a housing for intelligent completion devices, such as sensors or remote actuation devices. The invention can be used with expandable sand screens and in formation isolation completions.

[0038] Referring to Figure 7, if several seals elements 10 are placed in series (*i.e.*, two or more that are longitudinally offset), they will provide sealing redundancy and an opportunity to test the seals by placing a pressure gauge between the two seals and applying pressure within that

confined space. The change in pressure will yield information regarding the porosity of the surrounding rock and the integrity of each seal.

[0039] Another application is to inject fluid between the seals. This will allow an operator to inject chemicals to, for example, transform a soft, porous formation into a tight formation, increasing the efficacy of the seal not only at the seal face, but also in the vicinity of the packer near the injection site. Cement or some other chemical could be injected there.

[0040] Although only a few exemplary embodiments of this invention have been described in detail above, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention as defined in the following claims. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Thus, although a nail and a screw may not be structural equivalents in that a nail employs a cylindrical surface to secure wooden parts together, whereas a screw employs a helical surface, in the environment of fastening wooden parts, a nail and a screw may be equivalent structures. It is the express intention of the applicant not to invoke 35 U.S.C. § 112, paragraph 6 for any limitations of any of the claims herein, except for those in which the claim expressly uses the words 'means for' together with an associated function.